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ABSTRACT

Since the catastrophic subglacial lake outburst flood in 1892, the risk of a new event in the glacier of Tête Rousse, in the Alps (close to the Mont Blanc) has been thoroughly studied until now (Vincent et al., 2010, 2012). In the last 5 years, the combination of several geophysical technics has provided valuable input for the glaciologists to better understand the structure and the evolution of sub-glacial liquid water (Garambois et al, 2015). Ground penetrating radar which has proven for long to be a very efficient tool in glacial environment has been used here, providing fine imaging of internal structures, bed rock depth estimate, crevasses and the top of the main cavity. In addition, Magnetic resonance has been performed in 2009, confirming the existence of the liquid water volume, and applied in 2010 along a tight array of loops to provide a 3 D image and an estimate of the total water volume. Indeed, this latter parameter is of major importance to evaluate the level of risk.

Fig. 1, The "Tete Rousse glacier" is located at 3200m altitude, the equipment is installed during 10 days in a tent, and the operators installed the 80x80 m loops generally on the snow.

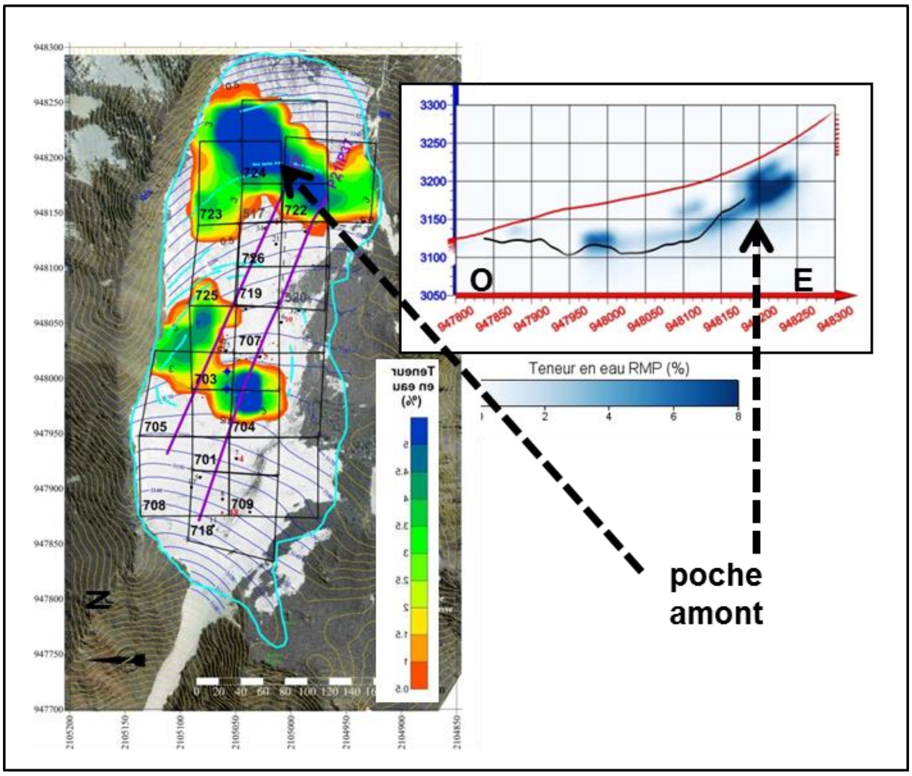

Fig. 2, Left, array of 14 loops performed in 2014 (black squares, 80 m side) allowing to map water content at depth (colorscale) and right, along a profile (altitude – distance)

Since 2010, once or twice a year, a complete 3D imaging of the glacier has been performed using magnetic resonance (Legchenko et al., 2014, Vincent et al., 2015). Comparison of water volumes with the yield of pumping performed in 2010, 2011 and 2012 has allowed to compare the vertical distribution of water estimated by MRS with the pumping. The correlation observed is excellent. Indeed, the total amount of water below the loop is directly the parameter measured by MRS. 3D imaging with MRS is affected by lack of sensitivity with depth, lateral resolution and the 3D model is not unique (Chevalier et al. 2014). But, when looking at cumulated water with depth, most of the equivalence issue is reduced.

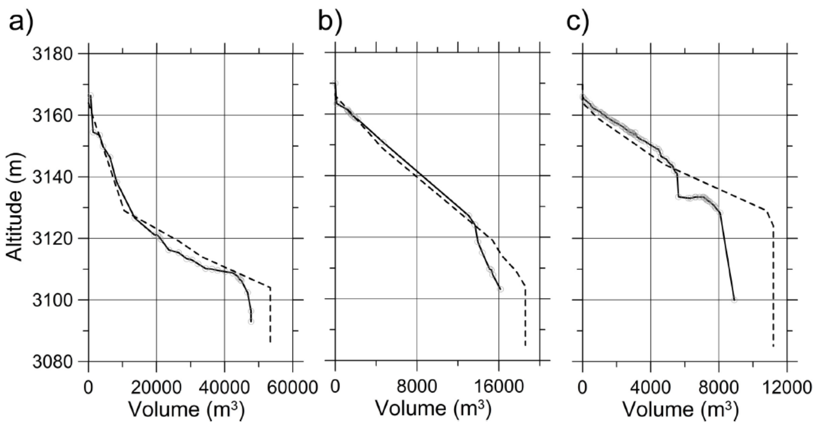

Fig. 3 Cumulated water volume with depth: comparison of 3D MRS estimate and in 2010, 2011 et 2012.

MRS as nowadays proved is usefulness in exploration in glacial environment (Lehmann-Horn et al., 2011, Nuber et al., 2013, Parsekian et al., 2013). But the repeated surveys on the Tete Rousse glacier has prove the efficiency for the monitoring issue when the dynamic of the water variation affects a significant volume, or if a large part is varying from frozen to liquid state. Further effort are to on-going to speed-up the measurements, improve the data quality for a better sensitivity, improve the arrays for better 3D resolution and study the MRS response of snow.

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